MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2016/2017

PPH 0105 – MODERN PHYSICS & THERMODYNAMICS

(All sections / Groups)

9 MARCH 2017
2.30 p.m - 4.30 p.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 3 pages excluding the cover page and the appendices with **FIVE** questions only.
2. Attempt **ALL** questions. Distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. All necessary workings must be shown.

Answer **ALL** questions.

Question 1: [10 marks]

a) For an ideal gas system, state the law that governs the relationship among the quantities; change in the internal energy of the system, the work done by the system, and the heat supplied to the system.

(2 marks)

b) It is known that 1.50 kg of steam occupies 2.55 m^3 at temperature of 100 °C and pressure of 1.0 atm and for the same mass of water occupies only 1.50×10^{-3} m^3. The specific latent heat of vaporization of water at 100 °C is 2.26×10^6 J/kg. Given that 1 atm = 101325 Pa and by considering a system consisting of 1.50 kg of water changing to steam at 100 °C and 1.0 atm, find

i) the heat supplied to the system,

(1.5 marks)

ii) the work done by the system, and

(2 marks)

iii) the increase in internal energy of the system.

(1.5 marks)

c) A window pane made of acrylic has dimensions of 1.20 m high, 1.80 m wide and 5.0 cm in thickness. The acrylic window has thermal conductivity of 0.20 W/m.°C. The temperature of the inner face of the acrylic window is 25.0 °C and that of the outer surface is 35.0 °C. What is the rate of heat flow through the acrylic window?

(3 marks)

Continued...

Question 2: [10 marks]

a) Diffraction grating is a device that can be used to determine the wavelength of a light source. In an experiment, an unknown light source is shone onto a diffraction grating of 2400 lines/cm. It is observed that the first bright line is at 0.095 m away from the central bright line on a flat screen. The distance between the grating and the screen is 0.55 m. What could be the wavelength (in nanometer) of that unknown light source?

(4 marks)

b) A thin converging meniscus lens has radii of curvature of the surfaces of R_1 = 15.0 cm and R_2 = 25.0 cm. The refractive index of the lens is 1.50. A 8.0 mm tall object is placed, perpendicular to the axis of the lens, at 90.0 cm to the left of the lens.

i) Sketch the converging meniscus lens and label R_1 and R_2.

(2 marks)

ii) Determine the position of the image formed.

(4 marks)

Question 3: [10 marks]

a) In the fusion reaction that takes place in the sun, hydrogen nucleuses are fused to create nucleus of helium. In the process, positrons ($_{+1}^{0}e$) and energy are released.

$$4\,{}_{1}^{1}H \rightarrow {}_{2}^{4}He + 2\,{}_{+1}^{0}e + \text{energy}$$

Given that the masses of ${}_{1}^{1}H$, ${}_{2}^{4}He$ and ${}_{+1}^{0}e$ are 1.007825 u, 4.002604 u, and 0.000549 u respectively, how much fusion energy in Joules will a mass of 10 g of Hydrogen (${}_{1}^{1}H$) produce? (molar mass of H is 1.0 g)

(5 marks)

b) Two radioactive nuclides X and Y are used in an experiment on the transport of nutrients in a plant. At the beginning, the number of nuclei of type X was the same as that of type Y. Three days later, there were 3.60 times more nuclei of type X than of type Y. If the isotope Y has a half-life of 1.25 days, what is the half-life, in days, of isotope X?

(5 marks)

Continued...

Question 4: [10 marks]

a) Two travelling waves in a long string can be described by wave equations

$$D_1(x,t) = 0.85\sin(15\pi t - 3\pi x)$$
$$D_2(x,t) = 0.85\sin(3\pi x + 15\pi t)$$

where the D_1, D_2 and x are in centimeters and t is in seconds.

i) Derive the equation of the resulting standing wave as a function of x and t.

(3 marks)

ii) Find the positions of the nodes and antinodes of the resulting standing wave.

(2 marks)

b) Explain what is Doppler effect?

(1 mark)

c) Horseshoe bats use Doppler effect to determine their location. A Horseshoe bat flies toward a wall at a speed of 20 m/s while emitting a sound frequency of 40 kHz. What is the beat frequency between the emission frequency and the echo? (Assuming that the speed of the sound in air is 343 m/s)

(4 marks)

Question 5: [10 marks]

a) When excited hydrogen atom is cooling down, the electron in a hydrogen atom makes a transition from a state $n = 5$ to the state $n = 2$.

i) What are the energy levels for $n = 5$ and $n = 2$?

ii) Calculate the energy of the photon emitted due to this transition.

iii) What is the wavelength of the photon emitted in unit of nanometer?

(5 marks)

b) A proton of mass 1.67×10^{-27} kg is made to move at high velocity by accelerating it through a potential difference of 10.0 kV. Calculate its de Broglie wavelength.

(5 marks)

End of Paper

APPENDIX I

Physical Constants

Quantity	Symbol	Value
Electron mass	m_e	9.11×10^{-31} kg
Proton mass,	m_p	1.67×10^{-27} kg
Elementary charge	e	1.602×10^{-19} C
Gravitational constant	G	6.67×10^{-11} N.m^2 /kg^2
Gas constant	R	8.314 J/K.mol
Hydrogen ground state	E_o	-13.6 eV
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Compton wavelength	λ_c	2.426×10^{-12} m
Planck's constant	h	6.626×10^{-34} J.s
Speed of light in vacuum	c	3.0×10^8 m/s
Rydberg constant	R_H	1.097×10^7 m^{-1}
Acceleration due to gravity,	g	9.81 m /s^2
Atomic mass unit (1u)	u	1.66×10^{-27} kg
Avogadro's number	N_A	6.023×10^{23} mol^{-1}
Threshold of intensity of hearing	I_o	1.0×10^{-12} W /m^2
Coulomb constant	k	8.988×10^9 N m^2 /C^2
Permittivity of free space	ε_o/κ_o	8.85×10^{-12} C^2/N.m^2
Permeability of free space	μ_o	$4\pi \times 10^{-7}$ H/m

Energy equivalent of atomic mass unit:

One atomic mass unit (1.0 u) is equivalent to 931.5 MeV

Earth:

Gravity	=	9.81 m s^{-2}
Radius	=	6.38 x 10^6 m
Mass	=	5.98 x 10^{24} kg

Moon:

Mass	=	7.35 x 10^{22} kg
Radius	=	1.74 x 10^6 m

Sun:

Mass	=	1.99 x 10^{30} kg
Radius	=	6.96 x 10^8 m

Mean distance from:

Sun to Earth	=	1.50 x 10^{11} m
Moon to Earth	=	3.85 x 10^8 m

APPENDIX II

List of Formulas

$\sin\theta_1 + \sin\theta_2 = 2\sin ½(\theta_1 + \theta_2)\cos ½(\theta_1 - \theta_2)$

$\cos\theta_1 + \cos\theta_2 = 2\cos ½(\theta_1 + \theta_2)\cos ½(\theta_1 - \theta_2)$

$\sin\left(\theta + \frac{\pi}{2}\right) = \cos\theta$

$\sin\theta \approx \tan\theta \approx \theta \ \ rad$ for small angle

$D(x, t) = D_M \sin(kx \pm \omega t \pm \phi)$

$v = \sqrt{\frac{F_\tau}{\mu}}$ $\qquad$ $v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}}$

$\lambda_n = \frac{2}{n}L$ $\qquad$ $f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$ $\qquad$ $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

$\frac{1}{f} = \left(\frac{n}{n_o} - 1\right)\left\{\frac{1}{R_1} - \frac{1}{R_2}\right\}$ $\qquad$ $d\sin\theta = m\lambda$ $\qquad$ $d\sin\theta = \left(m + \frac{1}{2}\right)\lambda$

$\lambda_m . T = 0.2898 \times 10^{-2}$ $\qquad$ $I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$

$E_n = -\frac{mk^2 Z^2 e^4}{2\hbar^2}\left(\frac{1}{n^2}\right)$ $\qquad$ $r_n = \frac{\hbar^2}{mkZe^2}n^2$ $\qquad$ $L = mvr_n = n\hbar$ $\qquad$ $\hbar = h/2\pi$

$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$ $\qquad$ $\frac{1}{\lambda} = \frac{mk^2 Z^2 e^4}{4\pi c\hbar^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$ $\qquad$ $\lambda = \frac{h}{p}$ $\qquad$ $\Delta E = hf$

$N = N_0 e^{-\lambda t}$ $\qquad$ $R = R_0 e^{-\lambda t}$ $\qquad$ $\lambda = \frac{\ln 2}{T_{½}}$ $\qquad$ $Q = (M_X - M_Y - M_a)\,c^2$

$\Delta L = \alpha\, L_0 \Delta T$ $\qquad$ $PV = nRT$ $\qquad$ $k = \frac{R}{N_A}$ $\qquad$ $Q = mc\Delta T$ $\qquad$ $Q = mL$

$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L}$ $\qquad$ $\frac{\Delta Q}{\Delta t} = e\sigma A T^4$ $\qquad$ $\frac{\Delta Q}{\Delta t} = Ie A\cos\theta$

$\overline{KE} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT$ $\qquad$ $U = \frac{f}{2}nRT$ $\qquad$ $\Delta U = \frac{f}{2}nR\Delta T$ $\qquad$ $Q = \Delta U + W$

$W = \int dW = \int_{V_i}^{V_f} P\,dV$ $\qquad$ $W = P(V_f - V_i)$ $\qquad$ $W = nRT\ln\left(\frac{V_f}{V_i}\right)$